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THEORY UNDERLYING THE PERIPHERAL VISION HORIZON DEVICE

by K.E. Money

Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West, P.O. Box 2000
Downsview, Ontario, Canada M3M 3B9

DEPARTMENT OF NATIONAL DEFENCE - CANADA

INTRODUCTION

A simple statement of the Peripheral Vision Horizon Device (PVHD) theory is that the likelihood of pilot disorientation in flight can be much reduced by providing a new kind of <u>artificial horizon</u> that will provide orientation information to <u>peripheral vision</u>. In considering the validity of this theory, three questions which are crucial are discussed:

(1.) Why was the artificial horizon chosen, instead of some other flight instrument?

(2.) Why is peripheral vision used instead of foveal vision?

(3.) Is there convincing evidence that peripheral vision is particularly well suited to the processing of orientation information?

THREE CRUCIAL QUESTIONS

1. <u>Why the artificial horizon?</u>

Disorientation is an error in the perception of orientation (motion, position, or attitude), usually an error in the

perception of <u>attitude</u> of the aircraft (1). The artificial horizon (part of the more modern "attitude director indicator") is the primary attitude instrument, the only one that gives both roll and pitch information, and the only one that gives the critical <u>pitch</u> information correctly under all conditions of flight. Normally, pitch information is derived also from the air speed indicator, the altimeter, the vertical speed indicator, and the G meter, but all of these four instruments give <u>incorrect</u> pitch information in some conditions of turbulence. Barring instrument unservicability, the artificial horizon <u>always</u> gives correct pitch information (14).

2. Why peripheral vision?

There are four benefits, four obvious advantages to providing orientation information to peripheral vision:

1) Peripheral vision is the kind of vision normally used for orientation and posture (9) and it is therefore well suited to the effortless and correct processing of orientation information. The intellectual effort of reading and interpreting the standard artificial horizon is also saved, a small saving under most circumstances of flight, but a major advantage in some disorientation situations in which severe psycho-

logical stress (9,12) or an increase in workload (6) can dramatically increase the viewing time required for perception. Also, the perceptual reversal of roll information from the standard artificial horizon, that occurs occasionally even in experienced pilots, is less likely to occur with a peripheral vision device.

2) Peripheral vision (ambient mode vision) still works well when the retinal image is blurred, as it often is by severe turbulence or vibration. Foveal vision (focal vision), on the other hand, fails rapidly as the clarity of the retinal image is degraded (9). Since disorientation is often provoked by severe turbulence with resulting vibration (10,14,15,16), it is better to provide anti-disorientation information to the visual mode that functions better when clarity of the retinal image is degraded. During some conditions of flight, in which certain kinds of vestibular stimulation occur, a reflex pseudo-myopia occurs, and this adverse optical effect (in some pilots) would also make the standard flight instruments difficult to read, with resulting predisposition to disorientation (11).

An ambient vision device is also easier to see in

turbulence and vibration simply because it is big.

3) Having provided attitude to ambient vision, focal vision then needs to be used for checking the standard artificial horizon much less frequently. This means that foveal vision can be used more for other things, and other things should then be done better.

4) With attitude information provided to ambient vision, the pilot is <u>continuously</u> receiving "artificial horizon information" no matter what else he is looking at. The <u>constant</u> provision of orientation information will, in all likelihood, reduce the frequency of the kinds of disorientation that are precipitated by unperceived changes in the attitude of the aircraft.

In instrument flying, the pilot uses his focal vision for many things, <u>one at a time</u>. With the standard artificial horizons, he receives "artificial horizon information" only during the fraction of his time that he is actually looking directly at the artificial horizon.

3. <u>What is the nature of the evidence that peripheral vision is particularly well suited to processing orientation information?</u>

There are five different kinds of evidence indicating that ambient vision (peripheral vision) is, normally, much more involved in orientation functions than is focal vision:

1) Studies of humans with discrete brain lesions have shown that people without focal vision can retain good ambient vision and good visual orientation and bodily equilibrium. These observations in humans have been confirmed by experiments with animals (9,13).

2) Postural tests have shown that ambient vision makes a much greater contribution to bodily equilibrium than does focal vision. Artificially imposed movement of the peripheral visual field can cause people to experience <u>self</u>-motion and to fall down, whereas movement of central visual fields has no such effects (7).

3) Ambient vision has been found to be much more important than focal vision in a variety of orientation/equilibrium phenomena, including circularvection, linearvection, and optokinetic nystagmus (2,3,4,5,7).

In some experiments, opposite information inputs have been provided to the ambient and focal systems, and the ambient system has always determined the orientational responses.

4) There are single neurons in visual areas of the brain that are responsive _only_ to _lines or edges_ that are _oriented_ at particular angles and _located_ to stimulate certain discrete parts of the retina. For some such single neurons (although possibly not most) the effective lines must stimulate a specific _peripheral_ area of the retina in order to provoke a response from the neuron (8).

5) Rotation of the peripheral visual field can actually cause systematic alteration of activity in certain "semicircular canal units" (neurons) in the vestibular nuclei in the brain stem. The vestibular nuclei are areas of the brain known to be largely concerned with orientation and self-motion; the fact that peripheral retinal areas are physically connected to these particular nuclei is good evidence that ambient vision is involved in orientation and self-motion (7).

THE BASIC DIFFERENCES BETWEEN FOCAL AND AMBIENT VISION

These differences have been summarized by Liebowitz and Dichgans (9).

FOCAL VISION	AMBIENT VISION
Answers the question "what".	Answers the question "where".
Small stimulus patterns, fine detail.	Large stimulus patterns.
Optical image quality and light intensity are important.	Optical image quality and light intensity are relatively unimportant.
Central retinal areas only.	Peripheral (and central) retinal areas.
Well represented in consciousness.	Not well represented in consciousness.
Serves object recognition and identification.	Serves spatial localization and orientation.

CONCLUSION

Because of the abundance of evidence, the dominant role of ambient vision (as opposed to focal vision) in orientation is now generally accepted by scientists working in this area. It is reasonable therefore to expect that an instrument for providing information about orientation will be more effective if it presents the information to peripheral retinal areas.

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